Kinetic Ballooning Instabilities in NSTX[1]

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The kinetic effects of trapped electron dynamics and ion Larmor radii are shown to give rise to a large stabilizing effect for kinetic ballooning instabilities (KBIs). The stabilizing effect is due to an enhanced parallel electric field and hence a parallel current that enhances the stabilizing field line tension by a factor proportional to the ratio of the total electron density to the untrapped electron density, n_e/n_{eu}. In comparison with the ideal MHD theory, the first stability β threshold for exciting KBI is increased and the second stability β threshold is reduced. For the low aspect ratio National Spherical Torus Experiment (NSTX) n_e/n_{eu} can be much larger than unity and the kinetic stabilizing effect can be significant. We have performed numerical KBI solutions based on a numerical baseline NSTX equilibrium with a weak reverse magnetic shear. The results show that KBIs are stabilized in most radial domain except around the weak reverse shear region ($0.28 < r/a < 0.37$) for the cases with or without temperature gradients. Moreover, in the unstable region the KBI growth rate is much smaller than the ideal MHD ballooning mode growth rate by more than a factor of 10. However, in the presence of energetic ions it is still possible that kinetic ballooning modes can be resonantly destabilized by the fast ions to large growth rates.

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